SECA INDUSTRY TEAMS

Delphi and Acumentrics, two of the SECA Industry Teams, have built and tested complete operating fuel cell systems. The developers are continually working to advance and improve their fuel cell technology to meet SECA target goals. For example, Delphi, the world's largest maker of auto parts, is collaborating with BMW to use SECA fuel cells for auxiliary power in their cars. Delphi is also collaborating with PACCAR, the manufacturer of heavy-duty, on- and off-road Class 8 trucks sold around the world, to use SECA auxiliary power units in its Kenworth trucks.

Delphi is developing a 5-kilowatt fuel cell for the distributed generation and auxiliary power unit markets. Delphi is applying its expertise in systems integration, high volume manufacturing and cost reduction. Delphi has demonstrated great progress making a very compact and lightweight system suitable for auxiliary power in transportation applications through subsystems and individual components integration. Delphi has improved upon its first generation fuel cell design multiple times, cutting weight and volume by greater than 50% from the first prototype demonstrated in a BMW automobile. Delphi has demonstrated fuel flexibility by using fuel gas extracted from coal and natural gas for tests on their different generations of fuel cell stacks. Delphi's progress has allowed it to meet SECA goals for power density while continuously improving the stack configuration.

Leading manufacturers of power generation equipment, such as General Electric and Siemens, and major automotive and truck manufacturers are investing in fuel cell business ventures to pursue growth in distributed generation and auxiliary power applications.

GE is evaluating several fuel cell stack designs with particular interest in large hybrid systems, combining SECA fuel cells with turbines. GE has been exceptionally impressive in improving fuel cell power density and fuel utilization using low-cost, conventional materials. These improvements are critical to lower cost with high efficiency. GE innovations also include multiple designs that minimize or eliminate difficult seal areas. GE has achieved Phase I SECA targets for stack power density and fuel utilization. Using a planar square SOFC stack, GE reached a power density of 404 mW/cm2 at an 88% fuel utilization, well over the SECA target (0.3 W/cm^2). In 2005, GE successfully completed their Phase I prototype test and will move into Phase II of the SECA program.

Cummins is developing SECA fuel cell products for recreational vehicles (RVs) that will run on propane using a compact fuel processing technology to convert the propane fuel to a hydrogen rich fuel stream. The team has produced a conceptual design for a fuel cell stack assembled from low cost "building blocks" that can be fabricated using ceramic manufacturing techniques used in the computer industry.

Siemens Power Generation changed their cylindrical SOFC design to dramatically increase cell power levels. The new flattened cells (HPD Cell-Delta 9) have much greater power output compared to their cylindrical tube counterparts. The new design reduces the size of the fuel cell so it can also be used for a wider range of applications, possibly even auxiliary power units. Siemens Power Generation has increased its power density with the flattened tubes, and is

working on the next generation of this design which will be smaller and more efficient than the flattened tubes.

FuelCell Energy brings twenty years of fuel cell experience to the SECA program. One promising approach to reducing solid oxide fuel cell cost is the use of less expensive materials by reducing the temperature. FuelCell Energy's team includes world-class researchers from the University of Utah, Materials and Systems Research, Inc. and PNNL. FuelCell Energy has jump-started their design using a University of Utah fuel cell, which has operated successfully for 10,000 hours. This Industry Team is targeting small stationary applications followed by military portable power applications, with an emphasis on multi-fuel capability.

Acumentrics has already attracted commercial interest in its fuel cells. In order to meet the SECA fuel cell cost target of $400 per kilowatt, Acumentrics is developing small tubular cell geometry with superior ruggedness and fast start capability. This team is focusing on development of a 10-kilowatt module targeting the communications, residential, military and light commercial markets. Acumentrics has demonstrated stable cell performance with low degradation rates over prolonged testing. They are already approaching SECA Phase III requirements for cell degradation.

The participating SECA industry team designs and their respective manufacturing techniques are summarized in Table 1:

Table 1. SECA Industry Team Design and Manufacturing Technology

Team	Design	Manufacturing
Cummins	• Electrolyte supported-planar • 825° C • Thermally matched materials • Seal-less stack	• Tape casting • Screen printing • Co-sintering
Delphi	• Anode supported-planar • 750° C • Ultra compact • Rapid transient capability	• Tape casting • Screen printing • 2–stage sintering
General Electric	• Anode supported-radial • 750° C • Hybrid compatible • Internal reforming	• Tape calendaring • 2–stage sintering
Siemens	• Cathode supported-flattened oval • 800° C • Seal-less stack	• Extrusion • Plasma spray
Acumentrics	• Anode supported-microtubular • 750° C • Thermally matched materials • Robust & rapid start-up	• Extrusion • Dip processing • Spray deposition • Co-sintering
FuelCell Energy	• Anode supported-planar • < 700° C • Low cost metals • Thermal integration	• Tape casting • Screen printing • Co-sintering • Electrostatic deposition